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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2020 /2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 433**

COURSE TITLE: **ENVIROMENTAL AND RENEWABLE ENERGY PHYSICS**

DATE: 20/07/2021 **TIME: 1300 – 1600 HRS**

INSTRUCTION TO CANDIDATES

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REGULAR – MAIN EXAM

PHY 433: GREEN ENERGY AND ENVIROMENTAL PHYSICS

STREAM: BED (Scie) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer the **TWO** question in **SECTION A** and any other **THREE** questions in **SECTION B.***

SECTION A (28 MARKS)

QUESTION ONE (14 Marks)

a) Define the following terms as used in solar radiations
   (i) Air mass (1 Mark)
   (ii) Albedo (1 Mark)

b) Highlight two major challenges facing the world's energy sectors at the moment (2 Marks)

c) Distinguish between renewable and nonrenewable sources of energy (2 Marks)

d) A hydro plant operates under an effective head of 100 m and a discharge of 200 m^3 /s. If the efficiency of the turbine alternator set is 0.9, find the power developed. (2 Marks)

e) The solar energy coming to the earth by radiation 1,340 W/m^2 when the temperature of the sun is 5800K. If the temperature of the sun decreases by 10.0%, what would be the amount of solar radiation coming to the earth? (3 Marks)

f) Determine the electrical power that can be generated from a wind turbine having a blade length of 52 m during a day when the wind speed is 12m/s if its power coefficient, is 0.4 (3 Marks)

QUESTION TWO (14 MARKS)

a) State two factors that determine the power capacity of hydropower plant (2 Marks)

b) Briefly explain how the following forms of energy can be harnessed
   i. Geothermal (2 Marks)
   ii. Tidal energy (2 Marks)

c) Waves in the ocean near the coast have an average height of about a meter, a frequency of about 0.1 Hz, wavelengths of about 10 m and speeds of about 1 m/s. Work out the wave energy associated with this information. (2 Marks)

d) Outline the mechanisms of efficiency loss in a solar cell at high temperatures (2 Marks)

e) Calculate the extraterrestrial insolation on a plane horizontal to the Earth's surface in Nairobi $1^0$16'S, $36^0$49'E) at solar noon on15th January. (3 Marks)

SECTION B (42 MARKS)

QUESTION THREE (14 MARKS)

a) Give the energy transformation that occur during power generation in a hydropower plant. (3 Marks)

b) State two types of hydropower plants when classified based on their loads (2 Marks)

c) A hydroelectric station is designed to operate at a mean head of 205 m and fed by a reservoir having a catchment area of 1000 km^2 with an annual rainfall of 125 m of which 80% is available for power generation. The expected load factor is 75%. Allowing a head loss of 5 m and assuming efficiency of turbine and generator to be 0.9 and 0.95 calculate suitable MW rating of the power station. (5 Marks)

d) The main section of the Sondu Miriu Dam in Nyanza is about 100 m tall, and the flow rate of water is about $1.1 \times 10^4 m^3/s$.

(i) How much power can be generated from the hydraulic head? (2 Marks)

(ii) How much power can be converted to electricity if the efficiency of the power plant is 81% (2 Marks)

QUESTION FOUR (14 MARKS)

a) Using well labelled diagram, explain the working principle of wind power plant. (3 Marks)

b) Use Newton's laws to show that the power contained in a "block" of wind with vertical surface area A and length x moving at velocity v is given by $P = \frac{1}{2}\rho A v^3$. (5 Marks)

c) If the wind speed is 11.5m/s and the speed after the turbine is 8m/s, what is the power extraction coefficient of this wind turbine? (3 Marks)

d) The rated output power for a turbine model at 15 m/s is 3 MW. The rotor diameter is 90m. The rotor rotates at a constant frequency of 0.198 Hz. Calculate the tip to speed ratio and power conversion coefficient of this model. (3 Marks)

QUESTION FIVE (14 MARKS)

a) Define the following terms:

(i) Quantum efficiency (1 Mark)

(ii) Recombination (1 Mark)

(iii) Short-circuit current (1 Mark)

b) Explain how the solar irradiance is affected by the Air mass (2 Marks)

c) Briefly describe the working principles of a conventional solar cell. (4 Marks)

d) State two major phenomena leads to a reduction in solar cell efficiency under real outdoor condition. (2 Marks)

e) The efficiency of a PV module under standard operating conditions is 12%. If the temperature coefficient of efficiency of the PV module is $\beta = 0.0045/^0C$, determine the value of its efficiency when the module temperature is 60^0C (3 Marks)

QUESTION SIX (14 MARKS)

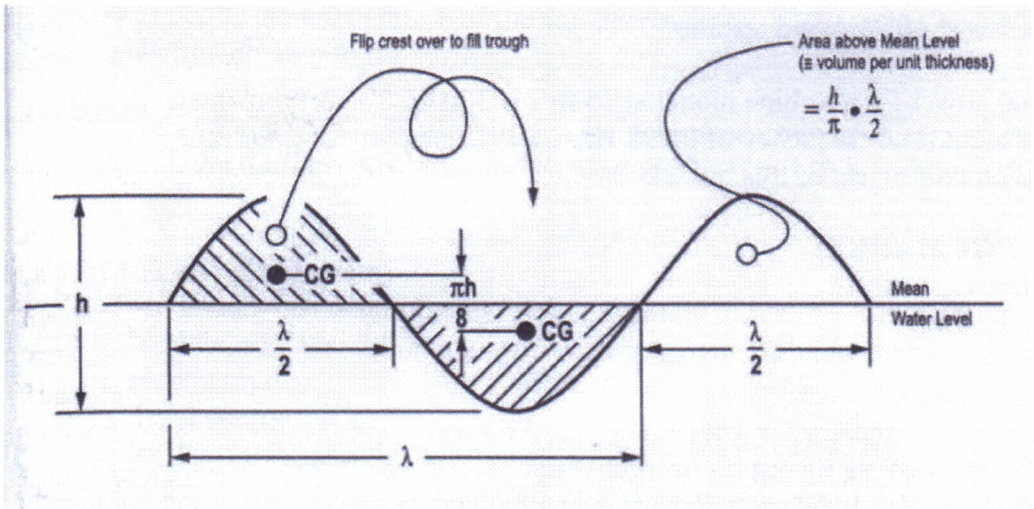
a) State the functions of the following component in a nuclear reactor.
   i) Moderators (1 Mark)
   ii) Control Rods (1 Mark)

b) Given that the atomic mass of ^{235}U = 235.04394 amu, n=1.008665 amu, ^{139}Xe = 138.9187869 amu, and ^{95}Sr = 94.9193582 amu
   (i) Calculate the mass deficit (Δ m) in atomic mass units (amu) of the following fission reaction $^{235}U + n \rightarrow {}^{139}Xe + {}^{95}Sr + 2n$ (2 Marks)
   (ii) Calculate the energy (MeV) released per one fission process (2 Marks)
   (iii) Calculate the energy released per kilogram of ^{235}U (2 Marks)
   (iv) If the uranium feed to a reactor has a U^{235} concentration of 3% and the spent fuel has a ^{235}U concentration of 0.8%, what mass of Uranium is required for a 1000 MW plant that runs for one year at a 95% capacity factor and an efficiency of 33% (4 Marks)

c) State two major disadvantages of nuclear power (2 Marks)

QUESTION SEVEN (14 MARKS)

a) State two types of ocean energies (2 Marks)
b) State two factors that affect the power generated by a wave (2 Marks)
c) Explain how the following categories of wave energy system generate energy
   (i) Oscillating water columns (2 Marks)
   (ii) Overtopping converters (2 Marks)
d) Suppose crest-to-trough height of wave is h, wavelength is λ, wave period is T, and the wave shape follows the sine function. Calculate wave power per unit length. (6 Marks)



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